TEST PROCEDURES

-OPTICAL DISTORTION TESTING OF WINDSHIELDS-

1.0 Background

1.1 Compound curvatures in modern automotive windshields (windscreens) often result in distortion which may confuse, disorient and, in extreme cases, cause illness of the driver and passengers. This condition may be even further exaggerated by the increased thickness and multiple laminations of bullet resistant (armored) windshields.

1.2 In the absence of a universally-accepted test procedure to evaluate this distortion, H.P. White Laboratory, Inc. originally prepared this standard in 1985 (HPW-TP-0500.00). In July of 1988, the procedures were revised and renumbered HPW-TP-0600.01.

1.3 This revision, HPW-TP-0600.02, does not alter the testing procedures. The changes incorporated in the standard by this revision include a change in name and format and the addition of background and discussion material only.

2.0 Discussion

2.1 While originally intended to evaluate armored automotive windshields, the procedures of this standard are readily-adaptable to other forms of transparent material including, but not necessarily limited, to non-armored automotive windshields.

2.2 The procedures are intended only to provide an objective procedure for evaluation purposes and to relate distortion of one windshield to another, but do not provide an acceptance/rejection criteria. The results of this test will provide an objectively-derived, numerical rating for each windshield which may be used to confirm or deny the acceptability of the windshield tested, but the acceptable numerical rating is to be established independent of this procedure.

3.0 Scope

3.1 The scope of this procedure is intended to objectively derive a numerical rating of the distortion created when viewing objects outside the automobile from positions within the automobile representative of a front and rear seat position.

3.1.1 The total viewing area is divided into two (2) areas for purposes of this evaluation - a 2.0 inch wide area immediately adjacent to the opaque mounting features (border area) and the remainder of the transparent area (principal viewing area).

3.1.2 The division of the transparent area into border and principal areas is to be without regard to the presence or extent of other features of the windshield such as tinting, imbedded heating elements, etc.

4.0 Test Sample

4.1 The test sample shall be a full size windshield appropriate for installation in the specified make, model and year of automotive vehicle.

4.2 In order to evaluate the ballistic resistance of the windshield, without destroying the windshield, the manufacturer may elect to provide two (2) coupons, not less than 12.0 inch x 12.0 inch, of the same material and laminar construction. The manufacturer shall certify and the test agency confirm the coupons and windshield are of the same construction.

4.3 The manufacturer shall provide the following information with his submission to the testing agency.

4.3.1 Make, model and year of automotive vehicle for which the windshield is intended.

4.3.2 The installation angle of the windshield with respect to the true vertical or horizontal plane - specifying which.

4.3.3 The extent that the opaque framing of the automobile protrudes into the viewing area - interior and exterior surfaces - of the full perimeter of the windshield.

5.0 Procedures

5.1 The optical distortion of the windshield (windscreen) shall be evaluated by viewing a grid-board at zero (0) degrees of obliquity through the windshield. The grid-board shall be 8.0 feet x 8.0 feet, painted flat white with a flat black 3.0 inch x 3.0 inch grid over its entire surface area. The assembly shall be positioned in the attitude of installation at a distance of 15.0 feet from the grid board.

5.2 Prior to conducting this, test the laminate configuration of the windshield and its dimensions shall be recorded. The edge of the sample shall be masked with an opaque tape to eliminate from the test those portions of the transparency which will be covered by framing and trim. Both the inside and the outside of the sample shall be masked and justification for the masking will be documented by an appropriate manufacturer’s drawing.

5.2.1 A heavy dark line, which will be discernible in subsequent photographs, will be applied to the surface of the windshield 2.0 inches inside of - and parallel to - the edge of the masked area.

5.2.2 For purposes of these tests, the portion of the transparency inside of this line is to be termed the PRINCIPAL VIEWING AREA and that area between this line and masked edge is to be termed the BORDER VIEWING AREA.

5.3 A suitable camera will be positioned with its view line horizontally oriented and passing through the vertical and horizontal center of the windshield and the approximate center of the grid board from a position 30.0 inches behind the center of the windshield.

5.3.1 The camera shall be fitted with a compatible lens which eliminates or minimizes lens-induced distortion in the film plane.

5.3.2 Two (2) exposures of the grid board will be made on the same film (double exposure) - one (1) directly and one (1) through the windshield - adjusting the ambient and flood lighting (if necessary) to produce sufficiently distinct film images to compare the two (2) images throughout the field of view.

5.3.3 Care must be taken to eliminate any camera displacement between exposures and the exposure time may have to be adjusted to compensate for tinting of the windshield.

5.4 Maintaining the horizontal view line of the camera, the camera will be rotated clockwise twenty (20) degrees and the grid-board repositioned to maintain its zero (0) degree obliquity with the camera’s view line. Another double exposure shall be made from this position.

5.5 The procedure shall be repeated at forty (40) degrees clockwise from the original (center) view and at twenty (20) and forty (40) degrees counterclockwise from that position (5 total photographs) comprising 10 total exposures).

5.6 The camera and grid-board shall be relocated on their original centered view line with the camera 96.0 inches behind the windshield and the above procedure repeated using the centered, twenty (20) degrees clockwise and twenty (20) degrees counterclockwise camera/grid-board orientations, only.

5.7 Each of the photographs shall be scored in accordance with the procedures of the attached data records (06-02-01, Pages 1 through 5) to determine the nature and extent of the optical distortion of the windshield.

6.0 Other Optical Defects

6.1 Other optical defects (i.e., open or entrapped bubbles, sand, lint, dirt, etc.) shall not be of a size or frequency in the assembly, to cause focusing of the viewer’s eye on such defects when viewing through the assembly. In no event shall any occlusion exceed 0.06 inches in diameter, nor appear at a frequency exceeding one (1) per square foot in the major viewing area of the assembly.

ARMORED AUTOMOTIVE WINDSHIELD DISTORTION TEST (HPW-TP-0600.02)

HPWLI Job No. _____ Date _____

Vendor: _____ Submitted By: _____
Vehicle Manuf.: _____ Model: _____ Year: _____
Submission Date: _____ Carrier: _____ Waybill: _____

Description: H_1 _____(in) W_1 _____(in) Four Corner Thickness (in)
H_2 _____(in) W_2 _____(in) _____, _____, _____, _____ (Avg. _____)
H_3 _____(in) W_3 _____(in)
H_4 _____(in) W_4 _____(in) θ _____(°)

Laminations: _____

A_T = Total Area = $\frac{H_1 + H_2}{2} \times \frac{W_1 + W_2}{2}$ = _____(in^2)

A_E = Effective (unmasked) Area = $\frac{H_3 + H_4}{2} \times \frac{W_3 + W_4}{2}$ = _____(in^2)

A_P = Principal Viewing Area = $\frac{H_3 -4 + H_4 -4}{2} \times \frac{W_3 -4 + W_4 -4}{2}$ = _____(in^2)

A_B = Border Viewing Area = $A_E - A_P$ = _____(in^2)

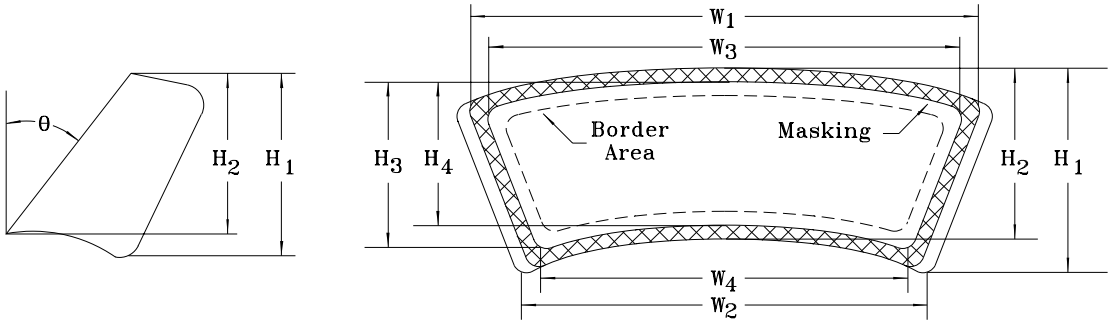

Figure 1. Typical Windshield Configuration

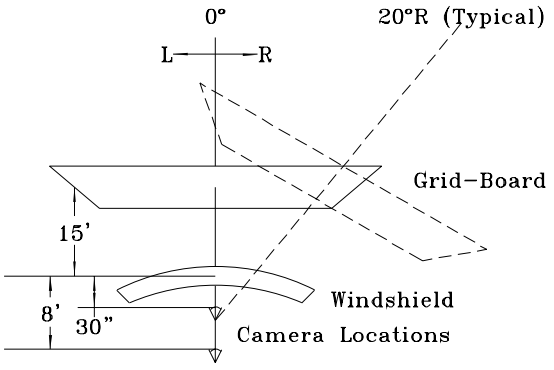

Figure 2. Test Set-Up

ARMORED AUTOMOTIVE WINDSHIELD DISTORTION TEST
(HPW-TP-0600.02)

HPWLI Job No. _____ Date _____

Photo	Principal Viewing Area (Front Seat)										Max. Indiv. Vert. or Horz.	Overall Total All Photos	Weighted Multi-plier	Scoring			
No.	A-2		A-3		A-4		A-5		A-6					Test Sample		Max Accept *	
Position	30"		30"		30"		30"		30"					Indiv. Photo	Overall Total All Photos	Indiv. Photo *	Overall Total All Photos *
Angle	0		20R		40R		20L		40L								
Area (ft^2)																	
Item	Hor.	Vert.	Hor.	Vert.	Hor.	Vert.	Hor.	Vert.	Hor.	Vert.							
01													1				
02													10				
03													100				
04													1				
05													10				
06													10/X				
07																	
08																*	*
Max.Accept		*		*		*		*		*							

Evaluation Factors (Item)

1. Maximum displacement of any one image line (inches).
2. Maximum displacement variation of any one image line (inches).
3. Maximum slope of any one image line.
4. Maximum slope reversals of any one image line.
5. Total slope reversals divided by area scored.
6. Ten divided by minimum distance between any two slope reversals of one line.
7. View angle rating - total of items 1 through 6.
8. Overall rating - total of horizontal (7H) plus vertical (7V).

* To be determined by procuring activity.

ARMORED AUTOMOTIVE WINDSHIELD DISTORTION TEST
(HPW-TP-0600.02)

HPWLI Job No. _____ Date _____

Photo	Border Viewing Area (Front Seat)										Max. Indiv. Vert. or Horz.	Overall Total All Photos	Weighted Multi-plier	Scoring			
No.	A-2		A-3		A-4		A-5		A-6					Test Sample		Max Accept *	
Position	30"		30"		30"		30"		30"					Indiv. Photo	Overall Total All Photos	Indiv. Photo *	Overall Total All Photos *
Angle	0		20R		40R		20L		40L								
Area (ft^2)																	
Item	Hor.	Vert.	Hor.	Vert.	Hor.	Vert.	Hor.	Vert.	Hor.	Vert.							
01													1				
02													10				
03													100				
04													1				
05													10				
06													10/X				
07											X	X	X	X	X	X	X
08													X			*	*
Max.Accept		*		*		*		*		*							

Evaluation Factors (Item)

1. Maximum displacement of any one image line (inches).
2. Maximum displacement variation of any one image line (inches).
3. Maximum slope of any one image line.
4. Maximum slope reversals of any one image line.
5. Total slope reversals divided by area scored.
6. Ten divided by minimum distance between any two slope reversals of one line.
7. View angle rating - total of items 1 through 6.
8. Overall rating - total of horizontal (7H) plus vertical (7V).

* To be determined by procuring activity.

ARMORED AUTOMOTIVE WINDSHIELD DISTORTION TEST
(HPW-TP-0600.02)

HPWLI Job No. _____ Date _____

Photo No.	Principal Viewing Area (Rear Seat)										Max. Indiv. Vert. or Horz.	Overall Total All Photos	Weighted Multi-plier	Scoring			
														Test Sample		Max Accept *	
Position	A-8 96"		A-9 96"		A-10 96"									Indiv. Photo	Overall Total All Photos	Indiv. Photo *	Overall Total All Photos *
Angle	0		20R		20L												
Area (ft^2)																	
Item	Hor.	Vert.	Hor.	Vert.	Hor.	Vert.	Hor.	Vert.	Hor.	Vert.							
01													1				
02													10				
03													100				
04													1				
05													10				
06													10/X				
07											X	X	X	X	X	X	X
08													X			*	*
Max.Accept		*		*		*		*		*							

Evaluation Factors (Item)

1. Maximum displacement of any one image line (inches).
2. Maximum displacement variation of any one image line (inches).
3. Maximum slope of any one image line.
4. Maximum slope reversals of any one image line.
5. Total slope reversals divided by area scored.
6. Ten divided by minimum distance between any two slope reversals of one line.
7. View angle rating - total of items 1 through 6.
8. Overall rating - total of horizontal (7H) plus vertical (7V).

* To be determined by procuring activity.

ARMORED AUTOMOTIVE WINDSHIELD DISTORTION TEST
(HPW-TP-0600.02)

HPWLI Job No. _____ Date _____

Photo	Border Viewing Area (Rear Seat)										Max. Indiv. Vert. or Horz.	Overall Total All Photos	Weighted Multi-plier	Scoring			
No.	A-8		A-9		A-10									Test Sample		Max Accept *	
Position	96"		96"		96"									Indiv. Photo	Overall Total All Photos	Indiv. Photo *	Overall Total All Photos *
Angle	0		20R		20L												
Area (ft^2)																	
Item	Hor.	Vert.	Hor.	Vert.	Hor.	Vert.	Hor.	Vert.	Hor.	Vert.							
01													1				
02													10				
03													100				
04													1				
05													10				
06													10/X				
07																	
08																*	*
Max.Accept		*		*		*		*		*							

Evaluation Factors (Item)

1. Maximum displacement of any one image line (inches).
2. Maximum displacement variation of any one image line (inches).
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